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News Briefs

General Developments

PARTNERS SOUGHT FOR "SHOP OF THE 90s"
NIST's "Shop of the 90s" is seeking industrial partners for its ongoing efforts to automate small machine shops. Hardware, software, and machine tool vendors who, under Cooperative Research Agreements, loan or donate equipment and/or expertise to the program, will have their products incorporated into an integrated manufacturing system geared to the needs of the nation's 127,000 struggling small machine shops. NIST is interested in forming partnerships in the following computer-aided areas: design, machining, inspection, fixtures design, shop management, cost estimation, process planning, local area networks, PC-based computer hardware and operation systems, computer numerical control machine tool retrofit, manual machine tool upgrades, machining and turning centers, cost justification and return-on-investment methodologies, third-party software enhancements, and training aids. For more information, contact Adrian Moll, Fabrication Technology Division, NIST, Gaithersburg, MD 20899, 301/975-6504.

TELESCOPES, LASERS AMONG USES FOR NEW THERMOCOUPLE
Two researchers have been granted a patent for a novel transparent thermocouple developed at NIST that can gauge critical temperatures on optical glass surfaces. Thermocouples are devices made of two dissimilar electrical conductors that indicate temperature by means of a voltage measurement taken between the two conductors. The NIST scientists invented the device for possible use as a sensor for high-quality glass such as that found on telescope lenses and laser mirrors. In the case of telescopes, slight temperature changes in lens glass could lead to expansion of the glass and possible distortion. By having a thermocouple in place on the glass that is optically transparent, this critical temperature could be monitored without significantly affecting the optical properties of the glass. With lasers, a thermocouple could be an integral part of a system, gauging temperature-related factors that could cause the laser beam to lose power. The new thermocouple is made of thin films of indium tin oxide and indium oxide that were "sputtered" a layer at a time. The team has been granted U.S. patent number 4,969,956.

FEEDBACK SOUGHT ON C VALIDATION SUITE
NIST seeks the views and recommendations of the C programming language community on a validation suite selected by NIST to validate conformance of C language processors to a voluntary industry standard (ANSI X3.159-1989). The C language standard is expected to be adopted as a Federal Information Processing Standard (FIPS) for use by agencies in procurements. NIST will make 20 trial use licenses of the Perennial ANSI C Validation Suite (ACVS) available to selected C users, implementors, developers, and researchers. Questions on the review procedure should be addressed to Kathryn Miles, 301/975-3156; EMAIL, miles@ecf.ncsl.nist.gov; or fax, 301/590-0932.

TIME AND FREQUENCY USER'S MANUAL UPDATED
NIST has just published a new edition of its popular Time and Frequency User's Manual. Written for readers at all levels of understanding, this edition contains updated information about time and frequency services available from NIST, other federal agencies, and other countries. The carefully indexed publication will be useful to technicians, experimenters, calibration laboratories, and scientists since it covers most aspects of receiving and using time and frequency calibration signals, the history

of time services, foreign transmitters, satellite services, and calibration methods. NIST SP 559 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-03050-3 for $8.50 prepaid.

TEST CHAMBER PERFORMANCE ENHANCED

NIST has enhanced the performance of its anechoic test chamber to extend to the millimeter wave region. The frequency range now extends to 40 GHz from 18 GHz. The chamber, a large shielded, metal-clad room covered with radio-frequency (rf) absorbers, is used to establish standard electromagnetic (EM) fields and to calibrate antennas, EM probes, and rf radiation hazard monitors. The chamber is available for use by industry and government agencies. A new publication, Generating Standard Reference Electromagnetic Fields in the NIST Anechoic Chamber, 0.2 to 40 GHz (NIST TN 1335), describes the chamber in detail and is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-03016-3 for $2.50 prepaid.

NIST HANDBOOK 133-THIRD EDITION UPDATED

The new supplement to NIST Handbook 133-Third Edition, Checking the Net Contents of Packaged Goods, 1989 is now available. The supplement compiles the latest amendments adopted by the National Conference on Weights and Measures (NCWM) at the annual meetings in 1989 and 1990. A list of the changes are provided in an addendum, along with instructions for replacing pages in the third edition of the handbook. NIST Handbook 133 is a procedural manual for inspectors in the compliance testing of net content statements on packages. Established in 1905, NCWM is an organization of state, county, city weights and measures enforcement officials, and industry representatives. NIST, a non-regulatory agency, provides technical assistance to NCWM through its Office of Weights and Measures. Copies of the supplement are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20204. Order by stock no. 003-003-03049-0 for $3.25 prepaid. Copies of NIST Handbook 133-Third Edition, 1989 are also available. Order by stock no. 003-003-02885-1 for $16 prepaid.

DIELECTRIC PROPERTIES CHARACTERIZED

Designers of microwave and millimeter wave devices must know the dielectric properties of many different materials. To measure these properties accurately, they must have valid methods and standard reference materials to calibrate their measuring instruments. NIST has long developed such methods and standards. A report, Dielectric Characterization and Reference Materials (NIST TN 1338) describes the national need for improving measurement of these materials and the parameters and conditions required for these measurements; desired properties of reference materials; factors that reduce dielectric performance and complicate measurements; and the theoretical basis for dielectric measurements. Recommendations for future research also are included. TN 1338 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-03029-5 for $6 prepaid.

PRODUCT DATA EXCHANGE KEY TO GLOBAL MARKETPLACE

Commerce Under Secretary for Technology Robert M. White called on American industry to join efforts to create an international product data exchange standard. Successful implementation of such a standard, he said, would "reduce costs, support total quality management, and provide a global competitive advantage for our products." White urged greater private-sector participation in research and deployment of the electronic product data exchange standard, called STEP, at CALS Expo '90 in Dallas, TX. STEP is a major element in the Defense Department's Computer-aided Acquisition and Logistics Support (CALS) program. The ability to digitally express and exchange all useful information about a given product is considered a key to computer-integrated manufacturing and concurrent engineering. STEP will enable users with different computers to contribute, to access, and to share mechanical, electrical, and structural information not previously available in a standard format. The American effort to develop STEP is called PDES. White also announced that the Commerce and Defense Departments had agreed on a joint action plan to spur product data exchange research in the United States, including expanding PDES research at the National PDES Testbed, headquartered at NIST.

REVIEWS SOUGHT FOR APPLICATION PORTABILITY PROFILE

A draft NIST Special Report, "Application Portability Profile (APP): The U.S. Government's Open System Environment (OSE) Profile," is now available for public review. This 51-page guide focuses on OSE and the federal government's APP, which integrates federal, national, international, and other specifications to accommodate the broad range of federal information technology requirements. The purpose of the document is to assist federal agencies in making informed choices on the selection and use of OSE specifications and in the development of application profiles based on the APP. The guide is intended for managers and project leaders with responsibilities for procuring, developing, and maintaining information systems supported by different applications. For a copy of the draft report send a self-addressed, stamped, 9.5" × 12" envelope with $1.65 in postage to NIST, ATTN: APP GUIDE, B266 Technology Building, Gaithersburg, MD 20899.

REGISTER OF CONFORMANCE TESTING LABS ANNOUNCED

NIST's Computer Systems Laboratory (CSL) has just announced the "Register of Conformance Testing Laboratories" under the auspices of the U.S. GOSIP (Government Open Systems Interconnection Profile) testing program. The laboratories that have been assessed and provisionally registered "pending NVLAP (National Voluntary Laboratory Accreditation Program) approval" are BULL HN (Phoenix, AZ), CDA Inc. (Vienna, VA), Corporation for Open Systems (McLean, VA), DEC (Littleton, MA), Hewlett-Packard (Cupertino, CA), IBM (Raleigh, NC), and The National Computing Centre (Manchester, U.K.). Each of these laboratories is now qualified to test products that are candidates for entry onto the NCSL Register of Conformance Tested GOSIP Products. The register is part of a larger testing program to ensure that networking products purchased by federal agencies comply with GOSIP. Federal agencies must use the GOSIP specifications in procuring networking products. For further information, contact Stephen Nightingale, 301/975-3616.

USDA ADOPTS NIST HANDBOOKS FOR NET WEIGHT LABELING

The United States Department of Agriculture's Food Safety and Inspection Service has issued a rule adopting two NIST handbooks for the net weight labeling of meat and poultry products. The rule amends the federal meat and poultry inspection regulations by incorporating by reference NIST Handbook 44-1991, Specifications, Tolerances, and Other Technical Requirements for Measuring Devices, and NIST Handbook 133-Third Edition & Supplement, Checking the Net Contents of Packaged Goods. The new rule will standardize weights and measures practices for the federal, state, and local governments for federally inspected meat and poultry products. It also will affect approximately 8,000 facilities in the United States and overseas. The NIST handbooks are inspection and procedures guides adopted by the National Conference on Weights and Measures (NCWM), an organization of federal, state, county, and city weights and measures enforcement officials and industry representatives. NIST provides technical assistance to NCWM through its Office of Weights and Measures.

MATERIALS TO HELP MEASURE MERCURY IN WATERWAYS

Gauging how much of a pollutant such as mercury is present in sediments of the nation's lakes and rivers can be tricky. To ensure accuracy, researchers ideally need an actual sediment sample containing a known quantity of the pollutant being measured. NIST now has such samples available for mercury measurements. With this new series of research materials (RMs), scientists can check the accuracy of their analytical instruments, and environmental investigators in different laboratories can be assured they are using the same homogeneous materials as standards. NIST acquired the sediment from various spots in the Tennessee River that had been subjected to industrial mercury discharges in the 1950s and '60s. One of the RMs (number 8406) contains only 0.06 μg per gram of mercury and is suitable as a "background" level. The other two (numbers 8407 and 8408) contain 50 and 107 μg per gram of mercury, respectively. Levels of numerous other elements are given for information only. The bottled 25-g RMs are $109 each from the Office of Standard Reference Materials, Rm. 204 Building 202, NIST, Gaithersburg, MD 20899, 301/975-6776.

OIML COMMITTEE MEETING

The International Committee of Legal Metrology (CIML) met in Porto, Portugal, Oct. 1990. Representatives of 38 of the 50 OIML member nations including United States/NIST participated in the meeting. The following OIML recommendations for measuring instruments were approved: high-precision line measures of length; indicating pressure, pressure-vacuum, and vacuum gauges; recording pressure, pressure-vacuum, and vacuum gauges; load cells (revision); atomic absorption spectrometers for measuring metal pollutants in water; and instruments for measuring vehicle exhaust emissions. The United States was primarily responsible for developing the last three recommendations. The OIML Certificate System for measuring instruments was also approved. This voluntary system is designed to assist instrument manufacturers in achieving approval of patterns of new measuring instruments that are marketed internationally. The system is also expected to assist legal officials responsible for pattern approval in various nations through mutual recognition of certificates of conformity and associated test reports that attest that instruments meet performance requirements of relevant OIML recommendations.

AN ACOUSTIC SENSOR FOR PROCESS MODELING AND PROCESS CONTROL OF HIGH-TEMPERATURE SUPERCONDUCTORS

An acoustic sensor has been developed at NIST for obtaining data for process modeling and process control of high-temperature ceramic superconductors. It was demonstrated that the ultrasonic sensor detects an increase of the stiffness of the sample when ordering takes place and when the non-superconducting ceramic (tetragonal, disordered structure) changes into a 90 K ortho I phase during long-term annealing. It was also found that on heating above the temperature at which the phase transformation from tetragonal to ortho I structure occurs, a second phase transition takes place. This transition has ultrasonic and kinetic features of a first order transformation. It was also shown that the same sensor can monitor in situ the acoustic emission produced by twinning and cracking and determine the sources and kinetics of these events.

CRITICAL EVALUATION OF SYMMETRY FOR SCIENTIFIC JOURNALS

Highly reliable new theory and scientific software have been developed by the NIST crystal and electron diffraction data center for the determination and evaluation of crystal symmetry. Application of the software to an analysis of all published structures has revealed that many crystal structures have been solved in the wrong crystal system. As many of these errors are now being corrected in the literature, the subject of missed symmetry has become a sensitive issue for both experimentalists and journal editors.

To prevent errors of this type in the literature, the International Union of Crystallography has invited NIST to install Symmetry software in its publication office in Chester, England. The objective is to evaluate systematically all structures as part of the editorial review process and thereby prevent the publication of incorrect crystal structure determinations.

CARS SPECTROMETER SYSTEM DEVELOPED FOR DYNAMIC TEMPERATURE AND PRESSURE MEASUREMENTS

An improvement of over an order of magnitude in detection sensitivity has been realized as a result of the development of a new coherent anti-stokes Raman spectroscopy (CARS) system by researchers at NIST. The impetus for this development is the goal of using selected molecules at dilute concentrations as internal primary standards for the measurement of transient pressure and temperature. This approach ultimately will allow pressure and temperature measurements to be made with a single laser pulse and thus provides a 20-ns temporal resolution. The new CARS system utilizes a unique configuration, which generates transform-limited single frequency pulses in a well-defined spatial mode. The result is a system with a spectral resolution of 30 MHz that displays outstanding peak signal-to-noise performance of at least 100:1. The accuracy of the spectral measurements obtained with this apparatus allows use of these molecular signatures as primary standards for temperature and pressure. The D_2 molecule in a N_2 host gas is the first chemical system to be developed for this application.

FEDERAL INFORMATION PROCESSING STANDARD (FIPS) SPECIFYING CODES FOR U.S. COUNTIES REISSUED

FIPS 6-4, Counties and Equivalent Entities of the United States, Its Possessions, and Associated Areas, provides the names and 3-digit codes that represent the counties and statistically equivalent entities of the 50 states, the District of Columbia, and the possessions and freely associated areas of the United States. A reissue of FIPS 6-3 incorporating technical changes, FIPS 6-4 is used in the interchange of formatted machine-readable data.

RESEARCHERS DEVELOP HAND-PRINTED CHARACTER DATABASE

NIST researchers have developed a handprinted character database consisting of 2,100 pages of bi-level, black and white, image data of handprinted numerals and text stored in compressed form on CD-ROM. The total image database, in uncompressed form, contains about 3 gigabytes of image data, with 273,000 numerals and 707,700 alphabetic characters. The handprinting sample was obtained from a selection of field data collection staff of the Bureau of the Census, with a geographic sampling corresponding to the population of the United States.

Prior to the development of the database, no large public source of test data for the design and evaluation of character recognition technology was available. The costs of manually keying in data for computer processing in government and the financial sector of the U.S. economy are presently estimated at $20 billion annually. Character recognition technology can significantly improve the productivity of these service sector activities. To date, 28 universities, industrial R&D laboratories, and users of character recognition technology have acquired the database.

FINAL REPORT OF 1989 COMPUTER SECURITY REVIEW PROJECT PUBLISHED

The Computer Security Act of 1987 requires federal agencies to prepare and submit for review security plans for unclassified computer systems that contain sensitive information. NISTIR 4409, 1989 Computer Security and Privacy Plans (CSPP) Review Project: A First-Year Federal Response to the Computer Security Act of 1987, describes the review effort that was conducted by a joint team from NIST and the National Security Agency in 1989. A summary report of the review project is available as an NIST National Computer Systems Laboratory (NCSL) Bulletin dated October 1990.

SERVICE TO THE NATIONAL PARTICLEBOARD ASSOCIATION

NIST was asked by the National Particleboard Association (NPA) to critique a procedure for calibrating formaldehyde levels in particleboard. The driving force is a HUD regulation that particleboard contain less than 0.3 ppm formaldehyde. The NPA runs a surveillance program in each member plant where formaldehyde level is estimated from in-situ measurements at production time via a calibration curve. A NIST scientist investigated the effect of measurement error and inhomogeneities in the particleboard on the calibration curve and outlined a statistical procedure for controlling the risks of rejecting a good product and of accepting material that is later found to have an unacceptable formaldehyde level.

NIST MEASUREMENTS BOOST HIGH-T_c SUPERCONDUCTIVITY

A NIST scientist has measured transport critical currents in excess of 200 A at a magnetic field of 30 T in oriented grained $YBa_2Cu_3O_7$ at liquid helium temperature (4.2 K). At 77 K, the measured critical current decreased but was still relatively high—more than 1,000 A/cm^2 at 30 T. The possibility of making practical magnets from high-critical-temperature superconductors depends (among other factors) on developing material that remains superconducting in high fields. The results of the NIST measurements provide the first direct demonstration that high transport critical currents can be achieved in high-critical-temperature superconductors at magnetic fields up to at least 30 T. The measurements were made with high-quality silver contacts and a high-current sample mount; high-magnetic fields were obtained using the hybrid magnet facility of the MIT National Magnet Laboratory. At 4.2 K, the critical current at 30 T exceeded the current capacity of the NIST apparatus, 200 A. No detectable voltage (i.e., less than about 2 μV) was observed along the superconductor at this maximum current. The corresponding critical current density was found to be in excess of 20,000 A/cm^2.

NIST MODEL FOR INSULATED GATE BIPOLAR TRANSISTORS IMPLEMENTED IN TWO COMMERCIAL CIRCUIT SIMULATORS

A NIST scientist in collaboration with private industry, has implemented a model for insulated-gate bipolar transistors (IGBTs) developed at NIST in a commercial circuit simulator program. Semiconductor device designers need models and simulators to help them develop efficient, competitive devices quickly and to reduce the need for expensive and time-consuming cut-and-try procedures. The IGBT is a new power semiconductor device that has found widespread acceptance as an alternative to metal oxide-semiconductor field-effect transistor, bipolar, and Darlington power-switching devices. The NIST scientist developed both the IGBT model and an associated software simulator called INSTANT, *I*GBT *N*etwork *S*imulation and *T*ransient *AN*alysis *T*ool. The model is unique in that it accurately

describes the static and dynamic behavior of the devices for general external circuit conditions.

The NIST scientist is also collaborating with workers at Virginia Tech's Power Electronics Center (VPEC) to implement the NIST IGBT model in a widely used circuit simulator known as IGSPICE. VPEC uses IGSPICE in collaboration with a number of U.S. electronics companies to develop new power electronic circuits and systems and has developed expertise in the use of IGSPICE for simulating power electronic circuits and in implementing new component models into IGSPICE.

NIST DEVELOPS TEST SUITE FOR DETERMINING CONFORMANCE TO BUILDING CONTROLS COMMUNICATION PROTOCOL

NIST has developed the first element, a test suite, of comprehensive procedures that could form the basis of an industry certification program for building control systems. Since early 1987, NIST scientists have been working cooperatively with the American Society of Heating, Refrigerating, and Air Conditioning Engineers to develop a consensus standard communication protocol for building automation and control systems. The standard, BACnet, is expected to be issued by the society for public review in early 1991. Once it is implemented widely within the industry, it will be possible for control systems of different manufacturers to be connected together and work effectively as part of an integrated system. The test suite is a collection of 65 test cases aimed at testing for conformance to an individual requirement in the proposed standard. A real hardware test system is now being built within the laboratories at NIST to assess the soundness of the test suite. Prototype controllers incorporating the provisions of the proposed standard will be used in the facility to refine the test cases and the test system to be used.

NEW DESIGN TOOL FOR OPTIMAL USE OF WINDOWS

A PC-based computer program for use in conjunction with a spreadsheet has been developed at NIST for building designers to select window systems that will balance and optimize their use of daylight to reduce the need for artificial lighting against their drain on heating and cooling energy. A database was established as a result of several hundred detailed computer simulations of commercial building energy use in five major climatic regions of the United States. The buildings simulated varied in wall and roof construction and included normal windows, those with sawtooth design, and skylights. The interior was lit with conventional fluorescent lighting that could be linearly dimmed to 30 percent of the peak lighting as natural daylighting is available. The program selects the optimum window areas for the location of interest, type of building, efficiency of heating and cooling, and local cost of energy.

EFFECT OF LIGHTING AND HVAC INTERACTIONS IN COMMERCIAL BUILDINGS

A full-scale test facility constructed in the large environmental chamber at NIST to simulate a commercial office space has been used by researchers in tests to document the extent to which control of the HVAC system and building interior furnishings can be varied to maximize lighting efficiency and minimize peak electrical loads. Approximately $50 billion is spent annually in the United States for lighting commercial buildings. Even a modest savings of 1 percent would produce a savings of $500 million. The light output and power consumption of the dominant commercial light source, the fluorescent lamp, can vary by as much as 20 percent dependent on the surrounding thermal conditions.

The test facility has been used to evaluate the effect of nine independent variables: lamp type, luminaire type, number of lamps per luminaire, room air temperature, airflow rate and airflow path in the vicinity of the luminaire, carpet, interior furnishings, and internal electrical loads. A report of the findings has been published for the Department of Energy.

NEW MATHEMATICAL PROCEDURE DEVELOPED FOR BUILDING THERMAL BRIDGES

NIST researchers have developed a new efficient mathematical technique for calculating energy transfer through thermal bridges in building facades that will lead to more accurate assessments of the energy impact of these construction details during design. Hour-by-hour energy simulation programs are typically used by designers to estimate how the annual energy consumption of their building will change with changes in design details. The programs calculate energy transfer through the building shell assuming one-dimensional transient heat conduction using the response factor technique. Research at NIST has shown that realistic construction practices lead to many cases of multidimensional heat conduction and penetrations through the facade, commonly called thermal bridges, that can negate energy conserving design

intentions. The conduction response factor technique was applied to five common cases: a built-up roof system with ceiling fasteners, a roof/wall interface, an insulated masonry cavity wall with metal studs, a floor slab that penetrates wall insulation, and a metal window frame/wall interface. The resulting response factors were verified by comparison with known energy transfer through these same elements under steady-state conditions and by transient calculation using classical finite-difference techniques. The impact of thermal bridges was demonstrated by the results. Where all five cases were incorporated within the same building, the overall energy transfer rate through the facade of the building increased by 33 percent. When the new technique is incorporated into commercially available energy simulation programs, designers should be much more sensitive to the effect of these design details.

BRIDGE BEARING TESTS CONDUCTED ON LARGE-SCALE TESTING FACILITY

Bridge bearings are used to support the superstructure of a bridge on the supporting piers and to absorb horizontal motions caused by thermal contraction and expansion and traffic-induced loads. NIST scientists recently completed tests on two large steel bridge bearings for the Florida Department of Transportation. The bearings will be installed in the concrete arched Acosta Bridge over the St. John's River. The NIST unique large-scale testing facility was used to conduct full-scale tests to determine the adequacy of the design, materials, and fabrication methods of the bearings under the design load. The first bearing was subjected to a vertical compressive load of about 12 million pounds, and the second bearing was subjected to a load of about 8.5 million pounds. The bearings were examined after the tests and found to be in acceptable condition for installation.

U.S. COMPANIES USE NIST ELLIPSOMETRIC PROGRAMS

Two computer programs—MAIN 1 and MAIN 2—for analyzing ellipsometer measurement data are in use by U.S. ellipsometer manufacturers and a reference material supplier. Both programs are the work of a NIST scientist. Ellipsometers are used in the semiconductor industry to measure the thickness of very thin films that are part of advanced semiconductor devices. An ellipsometer measures the phase shift that polarized light undergoes as it reflects from a flat sample. If the sample consists of thermally grown silicon dioxide on silicon, the phase shift provides a measure of the thickness and index of refraction of the silicon dioxide. To characterize multiple layers, phase-shift measurements are made at different wavelengths and incident angles of the polarized light. One manufacturer is using MAIN 1 and MAIN 2 to study the multiple layers of SIMOX (Separation by IMplanted OXygen) specimens, made by implanting silicon with oxygen to form a buried layer of silicon dioxide (SIMOX structures are also being investigated at NIST). Another company is creating an MS-DOS-compatible version of the two programs that it plans to provide with their ellipsometers. A third company is interested in modeling silicon dioxide on silicon Standard Reference Materials using MAIN 1, especially applied to the transition region which forms between the oxide layer and the silicon substrate.

NIST CONTRIBUTES TO NEW IEEE MEASUREMENT STANDARD FOR FIELDS AND IONS NEAR HIGH-VOLTAGE DC POWER LINES

NIST scientists made major contributions to the development of an Institute of Electrical and Electronics Engineers (IEEE) standard, IEEE Guide for the Measurement of DC Electric Field Strength and Ion Related Quantities, recently approved by the IEEE Standards Board. Publication of the new standard is expected in the autumn of this year. Speculation and concern during the early 1980s regarding possible environmental effects of electric fields and ions near high-voltage dc power lines focused attention on the measurement of the electric field strength and such ion-related parameters as the ion current density, monopolar charge density, and net space charge. No standard methods for determining these quantities existed, and the DC Fields and Ions Working Group of IEEE's Power Engineering Society, with NIST participation from the beginning, decided to prepare a draft standard that would provide appropriate guidance.

The results of numerous NIST laboratory studies have been incorporated into the text. This NIST role in the development of a measurement standard for dc power lines parallels earlier NIST involvement in the development of IEEE and International Electrotechnical Commission standards for characterizing ac power line electric and magnetic fields.

NIST COLLABORATION OPENS WAY FOR BREAKTHROUGH IN MACHINING FERROUS METALS

A guest researcher, in collaboration with researchers from NIST and Los Alamos National Laboratory, has demonstrated for the first time a means to machine extended-area optical-quality surfaces on stainless steel, a long-sought technique likely to have major significance as an advanced manufacturing technology. The technique involves diamond-turning, a machining process in which a single-crystal diamond is used as the cutting tool on a high-precision computer-controlled lathe. While many unsuccessful attempts have been made to develop a technique to diamond-turn steel and other ferrous metals, only one prior attempt has demonstrated even a partial success by machining in an acetylene atmosphere, producing only tiny areas of optical quality before interaction between the diamond of the tool and iron of the part destroyed the tool's cutting edge. Others have experimented unsuccessfully with externally applied liquid nitrogen cooling.

The research team was successful by machining with closed liquid-nitrogen cooling of both tool and sample. The sample consisted of a carefully chosen fine-grained stainless steel produced by powder metallurgy. An entire 1.5 in-diameter part—the limit of the apparatus—was machined with no apparent wear on the tool. This ongoing work is part of a study of the complex phenomena involved in diamond tool wear which limits the dimensional quality achievable in machining operation for some materials. Further laboratory work is required to determine the limits of the process in the machining of larger areas as well as of other ferrous metals. Potential applications of a fully developed process include direct machining of ferrous-metal components of, for example, optical scanners, video discs, surgical lasers, and space-based defense systems.

TERNARY REFRIGERANT MIXTURES EVALUATED AS REPLACEMENT FOR ENVIRONMENTALLY BANNED CFCs

The concept of a three-refrigerant mixture as a replacement for banned chlorofluorocarbons (CFCs) was demonstrated in tests conducted in the NIST breadboard heat pump facility. The use of ternary or higher order mixtures of refrigerants is gaining some attention in the refrigeration industry because they might allow the suppression of flammability in a single or binary mixture or allow the enhancement of a beneficial property such as oil solubility. The NIST tests focused on thermodynamic or efficiency improvements. Binary mixtures composed of components far apart in boiling points generally have a nonlinear relationship between temperature and entropy in the two-phase region. This results in large irreversibilities and inefficient heat exchange in evaporators and condensers. Introducing a third component can linearize this relationship and increase cycle efficiency when heat source and sink fluids are changing their temperatures linearly (water, brines, dry air, etc.). This concept was demonstrated in tests with a mixture of R22, R23, and R142b in which a system efficiency improvement of 28 percent relative to the use of the conventional single-component R22 was achieved.

NIST COMPLETES NEW EMULATOR/ TESTER FOR BUILDING CONTROLS IN COOPERATIVE INTERNATIONAL RESEARCH PROGRAM

Researchers at NIST have just completed the design and installation of an advanced building emulator/tester to be used in cooperative research with the U.S. building controls industry and organizations internationally. As part of a joint research program under the auspices of the International Energy Agency, researchers in the United Kingdom, Belgium, and Finland also have completed work on their own emulator/testers. Used much like flight simulators in the airline industry, the emulator/tester simulates a building, the weather, the HVAC system, and the heating/cooling plant in real time. It is connected to a building control system in place of the control system's sensors and actuators. The concept originally was conceived in the mid-1980s to evaluate a building control system's performance. NIST staff have demonstrated how the advanced emulator/ tester can be used to train new building controls operators, commission new controls software, assist in the development and debugging of new control algorithms, and tune local control loops. As the building industry becomes aware of these capabilities, it is anticipated that emulator/testers will become integral components of all future controls installations.

SMALL-ANGLE SCATTERING MEASUREMENTS OF CERAMIC MICROSTRUCTURE

NIST is undertaking Ceramics research to investi gate the processing/microstructure relationships in ceramics of technical importance in an effort to gain an improved understanding of the mechanisms

operative during ceramics processing. The characterization is being carried out using small-angle scattering techniques.

Small-angle neutron and x-ray scattering are well recognized techniques for the characterization of microstructure in the 1 to 100 nm range. This traditional size range, which is too low to include most of the microstructure relevant to ceramics research, has recently been extended to 10 μm for neutron scattering by theoretical developments and to 1 μm for x rays at NIST, and at Northwestern University. These complementary methods are currently being used to follow the evolution of ceramic microstructure as a function of thermal processing and to study the effects of starting chemistry, of additives, and of green body density. The intermediate sintering stage results on alumina, with or without additives, lend support to a stable topological model of sintering that is generally accepted. However, both the neutron and the x-ray results for the final sintering stage indicate coarsening in the residual pores, which is an unanticipated result, unless the grains are coarsening too.

WELDING AUTOMATION

In a cooperative program with industry and another government agency, NIST is developing through-arc sensors and signal analysis procedures to relate electrical measurements to weld arc stability. Such signals provide a relatively untapped source of information about the welding arc. Together with data from conventional vision or mechanical seam tracking sensors, these measurements contain much of the same sensory information that a welder receives during welding. The program being conducted by NIST also includes laser shadowing experiments and high-speed photography to confirm the physical meaning of the electrical signals. When combined with appropriate controls, these concepts will move the skilled welder to a machine operator's role, away from the heat and fume of the welding arc.

MODELING AND EXPERIMENTAL VERIFICATION OF MAGNETIC RECORDING

Since there is unremitting demand to increase the capabilities of magnetic storage devices (including disks and audio tapes), it is crucial to model the magnetic recording process. Until recently, there were two separate trends in modeling. Micromagnetic models characterize the media on a microscopic scale by numerically implementing the system of differential equations describing the behavior of the media. Phenomenological models efficiently describe the bulk behavior of the media while obscuring the physical principles. A new paradigm, the first to bridge this gap, models the bulk behavior of the media with pseudo particles, which are described micromagnetically. This representation, relating bulk behavior to the underlying material properties, has been experimentally tested at NIST using commercial samples. This is a collaborative project with George Washington University, where the theoretical work was performed.

WORKSHOP ON MICROELECTRONICS PACKAGING ADDRESSES POLYMER CURE

A NIST-industry workshop held at NIST, identified the need for improved measurement and control of polymer cure in the manufacture of microelectronics packaging. Control of cure during manufacture is central to maximizing mechanical, electrical, thermal, and transport properties of thermosets. Consequently, in terms of polymers and their interfaces with other materials, the greatest leverage is obtained by fostering development of techniques to monitor cure and of models that relate cure monitoring data to process control. The panel concluded that the trend towards manufacture of smaller devices implies that cure in very thin films and at interfaces with dissimilar materials are the most important areas for research. The panel also recommended that the most promising methods for NIST to explore were fluorescence techniques that use optical fibers to convey the excitation light to the sampling area. Other optical methods also were deemed to be fruitful areas of research, as well as dielectric techniques which are the basis for several designs of on-line sensors of cure in polymer composites manufacture.

MAGNETISM AND SUPERCONDUCTOR MATERIALS

Scientists from industry and NIST have been using neutron scattering to study novel properties of superconductors. While the discovery of high-temperature superconductivity has generated excitement for advancing technology, it also has introduced a new class of materials, which, at present, are not well understood. In this regard, neutron scattering has played a vital role because it can probe both structural and magnetic properties—the latter has been suspected as a possible underlying mechanism of high-temperature superconductivity.

The most recent neutron scattering work at the NIST reactor involves $Bi_2Sr_2MnO_y$, which is isostructural to Cu containing high-temperature superconductors. The replacement of Cu by the magnetic Mn ion, although suppressing superconductivity, allows the examination of the relationship between structure and the electronic properties.

At low temperatures, the neutron experiments have revealed long-range antiferromagnetic order along with two-dimensional critical scattering, which indicates that there is virtually no interaction between the antiferromagnetic sheets. When a magnetic field is applied, the ordering direction changes and a small ferromagnetic moment is observed. The results also suggest that the Mn valence is actually modulated by the layer bending superstructure, and this is the first observation of such an effect in these compounds.

Such studies of the effect of substituted elements on high-T_c superconducting properties are a key to tailoring these materials for technological applications.

NIST SCIENTIST AIDS INTERNATIONAL EFFORT TO DETECT RADIATION PROCESSED FOODS

A method based on electron spin resonance (ESR) spectrometry has been developed at NIST to detect foods treated with ionizing radiation. Paramagnetic centers specific to ionizing radiation are created in the bones of radiation-processed meats and can be measured by ESR. Thus, these centers may be used as a yes/no indicator of radiation treatment. In addition, ESR is capable of providing an estimate of the original absorbed dose to the bone. The method has also been applied successfully to certain shellfish (exoskeleton), fruits (seeds), and spices.

To date 37 countries, including the United States, have approved the use of ionizing radiation to treat foods for microbiological control, deinfestation, and shelf-life extension. In response to worldwide concerns about the international trade of irradiated foods, the International Atomic Energy Agency has organized a coordinated research program, Analytical Detection Methods for the Irradiation Treatment of foods (ADMIT). The goal of ADMIT is to develop an array of physical, chemical, and biological tests that will enable government regulatory agencies to detect radiation-processed meats, fruits, spices, and dry foodstuffs. Recently, at the first ADMIT meeting near Warsaw, Poland, a NIST scientist, was selected to head the ESR special study group of ADMIT and coordinate upcoming international trials of the method.

DETECTION OF GUNSHOT AND EXPLOSIVE RESIDUES

NIST research has shown that micellar electrokinetic capillary electrophoresis (MECE) has great potential for addressing the historically difficult problem of detecting and identifying organic residues as evidence of the use of handguns and/or high explosives. Using the MECE technique, 26 of the major components contained in gunpowders and explosives have been separated and detected in under 10 minutes, with the sensitivity required for most residue analyses. This technique has been applied to swabbings from spent ammunition shell casings. Several of the characteristic gunpowder components were identified, including nitroglycerin.

This new technique is based on capillary electrophoresis (CE), where compounds are separated by their relative movement through an electrolyte in a small-diameter capillary tube, under the influence of a high electric field. Normally in CE, separation occurs as a result of differences in both the charge and size of the molecules. Since neutral species have no charge, they are not retained and therefore no separation is possible. However, using MECE, neutral molecules can be separated by the addition of charged encapsulating agents (micelles) to the electrolyte. Since the charged micelles move at a rate that is different from the bulk electrolyte, differences in the distribution of the residue molecules between the bulk and micellar phases provide the basis for rapid, high-resolution separations.

Every individual gunpowder and explosive formulation contains a complex mixture of organic propellants, plasticizers, and stabilizers. The high-resolution separation of these mixtures can provide an unambiguous chemical fingerprint for each material.

Current work includes cataloging the fingerprint patterns of several brands of commercial reloading powders and explosives, as well as identifying the organic gunshot residues from hand swabs.

FIRST FEMTOSECOND LASER MEASUREMENTS OF VIBRATIONAL RELAXATION OF ADSORBED MOLECULES

Recent experiments at NIST have provided the first direct determination of the rate of energy transfer for vibrationally excited molecules adsorbed at well-characterized metal single-crystal surfaces. These experiments address effects that previously have been accessible only through theoretical models or indirect measurements. The NIST experiments, performed with femtosecond laser pulses, have special significance because the energy dissipation processes at surfaces are expected to play a profound role in the chemical and physical behavior of interfaces.

In these femtosecond infrared pump-probe experiments, an ordered monolayer of CO is adsorbed on a well-characterized Pt(111) single crystal surface. An infrared pump pulse excites the adsorbed CO stretch mode (2105 cm^{-1}), and a second infrared probe pulse is used to characterize the time evolution of the excited state. Among the observed effects was the rapid ($T_1 \approx 3$ ps) decay of the excited state population. This decay is extraordinarily rapid compared to that for CO oscillators in other materials, indicating that a mechanism unique to conducting surfaces is at work. Presumably, the energy is lost to electronic states of the metal (electron-hole pairs). This mechanism had been predicted to give decay rates comparable to the observed rates but had not been observed previously.

These experiments demonstrate the power of time-resolved measurements for directly monitoring energy redistribution among molecular bonds at surfaces. Such measurements promise to elucidate energy- transfer processes at surfaces, a field where direct information has been elusive. Similar techniques are being developed to measure the deposition of energy at surfaces during chemical processing.

LASER-DRIVEN SURFACE CHEMISTRY: THE CRITICAL ROLE OF SURFACE ELECTRONIC STATES IDENTIFIED

Recent NIST work has led to the first identification of an optically initiated chemical reaction which is driven by creation of excited electronic states found only at surfaces. In these experiments, a Si(111) crystal was prepared in ultrahigh vacuum and covered with 5 percent of a monolayer of NO. A 10 ns laser pulse irradiated the surface, desorbing a small fraction of the bound NO. A second laser pulse was then used to identify the velocity and internal state distribution of the ejected NO. Since the temperature of the surface increased by less than 1 K, it was apparent that the desorption was not thermally induced. By using quantum-state-specific detection of the desorbed NO, the researchers learned that the NO had an unusual internal energy content, exhibiting velocities that exceeded the surface temperature by up to a factor of 15, and a spin-orbit population that was not equilibrated with molecular rotation. Additional experiments that probed the sensitivity of this optically driven desorption process to the wavelength of light used for irradiating the crystal established that the desorption yield did not correlate with the bulk absorption properties, but were best accounted for by previously identified electronic states localized at the surface. The role of these surface states was confirmed by chemical titration of specific surface states.

The observation of optically driven, surface-state mediated, chemical reactions has interesting implications for the field of laser/surface processing. Reaction pathways involving optically accessed surface states can proceed with minimal substrate heating, providing new opportunities for low-temperature processing. In addition, their localization to the illuminated area may provide better spatial resolution compared to reactions stimulated by bulk substrate excitations.

INVITATIONAL WORKSHOP ON SECURITY LABELS FOCUSES ON THE GOVERNMENT OPEN SYSTEMS INTERCONNECTION PROFILE (GOSIP)

A recent 2-day workshop on security labels in open systems was attended by representatives from the Department of Defense, the Department of Energy, NIST, and several private companies. Discussions centered on security labels in open-end systems, database applications, and networks, and on requirements for a labeling standard for Open Systems Interconnection, acceptable to the classified and unclassified communities, to be considered for incorporation into FIPS 146, GOSIP. Workshop proceedings have been published as NISTIR 90-4362, Security Labels for Open Systems—An Invitational Workshop.

VOLTAGE-CURRENT SIMULATOR HELPS RESOLVE MEASUREMENT ISSUES FOR SUPERCONDUCTOR CRITICAL CURRENT

A NIST scientist has developed electronic analog circuits that simulate the current-voltage characteristics of superconductors that are undergoing

the transition from the superconducting state to the normal state at the critical current. The original purpose in implementing the simulator was to assist the development and evaluation of large-current superconductor test systems. NIST researchers found that, when applied to a set of measurements, the simulator can differentiate between problems arising from the performance of measurement systems as contrasted with problems arising from the characteristics of the specimen superconductors themselves. This result is particularly useful for studies of ceramic high-critical-temperature superconductors in which it may be difficult to identify the source of problems. For example, the recent round-robin interlaboratory comparison of critical-current measurements on high-T_c superconductors organized by another government agency showed a wide scatter of results, partly because of the idiosyncrasies of the measurement systems, some of which were assembled without the benefit of much experience with superconductors, and partly because of the variations and instability of the specimen superconductors that were measured. NIST expects that application of the simulator will make a strong contribution to bringing consistency and order into the field of critical-current measurements.

Calibration Services

NEW STEADY-STATE HIGH-CURRENT CALIBRATION CAPABILITY ESTABLISHED

NIST has developed capability and an associated special-test measurement service for steady-state current calibration up to about 20 kA, primarily for calibration and evaluation of current transformers used as transfer standards by the electric power industry. Utilities use these standards in turn to evaluate current transformers used for revenue metering purposes to step down currents at levels of thousands of amperes to typical measurement levels of about 5 A. With energy costs and consumption steadily rising, the utility industry has urgent needs for accurately measuring current and energy at very high currents.

The new NIST measurement system can now generate steady-state currents at over 20 kA, with measurement uncertainties of less than 0.01 percent; the previous current limit was about 6 kA. The new capability results from replacement of a motor-generator set with an electronic power source and incorporation of air- and water-cooled buses for removing heat when sustained measurements are made at currents greater than about 8 kA. This electronic source has drive capabilities of 54 kVA maximum at power-line frequencies and can be used at reduced rating to frequencies as high as 5 kHz. The facility has already been used to complete a calibration for a utility customer at 12 kA.

Standard Reference Data

NEW STANDARD REFERENCE DATABASE FOR ADVANCED CERAMICS

A new structural ceramics database (SCD) for personal computers (PCs) is designed to speed the application of high-temperature advanced ceramic materials from the laboratory to the marketplace. The database was developed by NIST materials scientists. SCD provides design engineers with rapid access to important information on the thermal and mechanical properties of silicon carbide and silicon nitride monolithic materials. These materials are primary candidates for the manufacture of heat exchangers, ceramic engine components, sensors, and cutting tools because of their high strength and dimensional stability, chemical inertness, and wear resistance. NIST Structural Ceramics Database (SCD), Standard Reference Database 30, is available for $495.